

METHOD AND APPARATUS FOR SHORT-SLOT-CYCLE PAGING

FIELD

[0001] The present invention relates to point to multi-point communications systems. More specifically, the present invention relates to methods and apparatus for providing short-slot-cycles paging of a group of target mobile stations.

BACKGROUND

[0002] In wireless communications systems, registration is the process by which a mobile station notifies a base station of its location, status, identification, slot cycle, and other characteristics. The mobile station informs the base station of its location and status so that the base station can efficiently page the mobile station when establishing a mobile station-terminated call. Paging a mobile station includes the act of seeking the mobile station when a call has been placed to that mobile station. To reduce call set up in some applications, it is desirable to minimize registration and paging cycles.

[0003] For example, a class of wireless services intended for quick, efficient, one-to-one or one-to-many (group) communication has existed in various forms for many years. In general, these services have been half-duplex, where a user presses a “push-to-talk” (PTT) button on a phone/radio to initiate a group call. If granted the floor, the talker then generally speaks for a few seconds. After the talker releases the PTT button, other users may request the floor. These services have traditionally been used in applications where one person, a “dispatcher,” needs to communicate with a group of people, such as field service personnel or construction site workers, which is where the “dispatch” name for the service comes from. Similar services have been offered on the Internet and are generally known as “voice chat.” A key feature of these services is the desirability of quick call set ups. Therefore, registration and paging need to be optimized accordingly.

[0004] There is a need, therefore, for mechanisms to shorten paging cycles for paging a group of target mobile stations.

SUMMARY

- [0005] The disclosed embodiments provide novel and improved methods and apparatus for providing short-slot-cycle paging of mobile stations in a wireless communication network. In one aspect, a method in a communication device (CD) for providing short-slot-cycle paging includes receiving system parameter messages from a base station (BS), determining whether the BS is capable of short-slot-cycle paging, and indicating that the CD is also capable for short-slot-cycle paging, if the BS is determined to be capable of short-slot-cycle paging. The method further includes setting a negative slot-cycle-index value for the short-slot-cycle paging.
- [0006] In one aspect, a method in a BS for providing short-slot-cycle paging includes indicating to a CD that the BS is capable of short-slot-cycle paging, receiving information from the CD, indicating that the CD is also capable for short-slot-cycle paging, and paging the CD based on the received information.
- [0007] In one aspect, an apparatus for providing short-slot-cycle paging includes a memory unit, a receiver, a transmitter, and a processor communicatively coupled with the memory unit, the receiver, and the transmitter. The processor is capable of carrying out the above-mentioned methods.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0008] The features and advantages of the present invention will become more apparent from the detailed description of disclosed embodiments set forth below when taken in conjunction with the drawings, and wherein:
- [0009] FIG. 1 illustrates a group communications system;
- [0010] FIG. 2 illustrates an embodiment for a base station and a mobile station operating in FIG. 1;
- [0011] FIG. 3 illustrates how several communication devices interact with a group call server;
- [0012] FIG. 4 illustrates a call-setup process according to one embodiment;
- [0013] FIG. 5 illustrates one embodiment for slot cycle arrangement;
- [0014] FIG. 6 illustrates a flow diagram for providing short-slot-cycle paging in a base station;
- [0015] FIG. 7 illustrates a flow diagram for providing short-slot-cycle paging in a mobile station;

- [0016] FIG. 8 illustrates a flow diagram for providing short-slot-cycle paging in a base station;
- [0017] FIG. 9 illustrates a flow diagram for providing short-slot-cycle paging in a mobile station.
- [0018] FIG. 10 illustrates a flow diagram for providing short-slot-cycle paging in a base station; and
- [0019] FIG. 11 illustrates a flow diagram for providing short-slot-cycle paging in a mobile station.

DETAILED DESCRIPTION

- [0020] Before several embodiments are explained in detail, it is to be understood that the scope of the invention should not be limited to the details of the construction and the arrangement of the components set forth in the following description or illustrated in the drawings. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.
- [0021] FIG. 1 illustrates a functional block diagram of a group communication system **100**, for implementing one embodiment. Group communication system **100** is also known as a push-to-talk (PTT) system, a net broadcast service (NBS), a dispatch system, or a point-to-multi-point communication system. In one embodiment, group communication system **100** includes a group call server **102**, which may be deployed in either a centralized deployment or a regionalized deployment.
- [0022] Group communication devices (CDs) **104** and **106**, which may be deployed such as cdma2000 handset, for example, may request packet data sessions using a data service option. Each CD may use the session to register its Internet Protocol (IP) address with the group call server to perform group call initiations. In one embodiment, group call server **102** is connected to the service provider's packet data service nodes (PDSNs) through a service provider's wide area network **116**. CDs **104** and **106**, upon requesting packet data sessions from the wireless infrastructure, may have IP connectivity to group call server **102** through a PDSN **114**. The PDSNs provide interface between transmission of data in the fixed network and the transmission of data over the air interface. Each PDSN may interface to a base station controller (BSC) through a packet control function (PCF) **108** and a network **112**. The PCF may be co-located with the BSC within a base station (BS) **110**.

[0023] A packet data service node may fall in one of several states, e.g., active or connected state, dormant state, and null or inactive state. In the active or connected state, an active traffic channel exists between the participating CD and the BS or BSC, and either side may send data. In the dormant state, no active traffic channel exists between the participating CD and the BSC, but a point-to-point (PPP) link is maintained between the participating CD and the PDSN. In the null or inactive state, there is no active traffic channel between the participating CD and the BSC, and no PPP link is maintained between the participating CD and the PDSN.

[0024] After powering up, CDs **104** and **106** may request packet data sessions. As part of establishing a packet data session, each CD may be assigned an IP address. Each CD may perform a registration process to notify group call server **102** of the CD's IP address. Registration may be performed using an IP protocol, such as session initiation protocol (SIP) over user datagram protocol (UDP). The IP address of a CD may be used to contact the CD when the corresponding user is invited into a group call.

[0025] Once a group call is established, CDs **104** and **106** and group call server **102** may exchange media and signaling messages. In one embodiment, media may be exchanged between the participating CDs and the group call server by using real-time protocol (RTP) over UDP. The signaling messages may also be exchanged by using a signaling protocol over UDP.

[0026] Group communication system **100** performs several different functions in order to operate group call services. The functions that relate to the user side include user registration, group call initiation, group call termination, sending alerts to group participants, late join to a group call, talker arbitration, adding members to a group, removing members from a group, un-registering a member, and authentication. The functions that relate to system preparation and operation include administration and provisioning, scalability, and reliability.

[0027] FIG. 2 is a simplified block diagram of an embodiment of base station **204** and mobile station **206**, which are capable of implementing various disclosed embodiments. For a particular communication, voice data, packet data, and/or messages may be exchanged between base station **204** and mobile station **206**, via an air interface **208**. Various types of messages may be transmitted, such as messages used to establish a communication session between the base station and mobile station, registration and paging messages, and messages used to control a data transmission (e.g., power control,

data rate information, acknowledgment, and so on). Some of these message types are described in further detail below.

- [0028] For the reverse link, at mobile station **206**, voice and/or packet data (e.g., from a data source **210**) and messages (e.g., from a controller **230**) are provided to a transmit (TX) data processor **212**, which formats and encodes the data and messages with one or more coding schemes to generate coded data. Each coding scheme may include any combination of cyclic redundancy check (CRC), convolutional, turbo, block, and other coding, or no coding at all. The voice data, packet data, and messages may be coded using different schemes, and different types of messages may be coded differently.
- [0029] The coded data is then provided to a modulator (MOD) **214** and further processed (e.g., covered, spread with short PN sequences, and scrambled with a long PN sequence assigned to the user terminal). The modulated data is then provided to a transmitter unit (TMTR) **216** and conditioned (e.g., converted to one or more analog signals, amplified, filtered, and quadrature modulated) to generate a reverse link signal. The reverse link signal is routed through a duplexer (D) **218** and transmitted via an antenna **220** to base station **204**.
- [0030] At base station **204**, the reverse link signal is received by an antenna **250**, routed through a duplexer **252**, and provided to a receiver unit (RCVR) **254**. Base station **204** may receive registration information and status information, e.g., mobile station mobility rate, from mobile station **206**. Receiver unit **254** conditions (e.g., filters, amplifies, down converts, and digitizes) the received signal and provides samples. A demodulator (DEMOD) **256** receives and processes (e.g., despreads, decovers, and pilot demodulates) the samples to provide recovered symbols. Demodulator **256** may implement a rake receiver that processes multiple instances of the received signal and generates combined symbols. A receiving (RX) data processor **258** then decodes the symbols to recover the data and messages transmitted on the reverse link. The recovered voice/packet data is provided to a data sink **260** and the recovered messages may be provided to a controller **270**. Controller **270** may include instructions for paging a group of mobile stations, providing short-slot-cycle paging, indicating to a MS that the BS is capable of short-slot-cycle paging, receiving information from the CD, indicating that the CD is also capable for short-slot-cycle paging, and paging the CD based on the received information.

[0031] The processing by demodulator 256 and RX data processor 258 are complementary to that performed at mobile station 206. Demodulator 256 and RX data processor 258 may further be operated to process multiple transmissions received via multiple channels, e.g., a reverse fundamental channel (R-FCH) and a reverse supplemental channel (R-SCH). Also, transmissions may be simultaneously from multiple mobile stations, each of which may be transmitting on a reverse fundamental channel, a reverse supplemental channel, or both.

[0032] On the forward link, at base station 204, voice and/or packet data (e.g., from a data source 262) and messages (e.g., from controller 270) are processed (e.g., formatted and encoded) by a transmit (TX) data processor 264, further processed (e.g., covered and spread) by a modulator (MOD) 266, and conditioned (e.g., converted to analog signals, amplified, filtered, and quadrature modulated) by a transmitter unit (TMTR) 268 to generate a forward link signal. The forward link signal is routed through duplexer 252 and transmitted via antenna 250 to mobile station 206. Forward link signals include paging signals.

[0033] At mobile station 206, the forward link signal is received by antenna 220, routed through duplexer 218, and provided to a receiver unit 222. Receiver unit 222 conditions (e.g., down converts, filters, amplifies, quadrature modulates, and digitizes) the received signal and provides samples. The samples are processed (e.g., despreaded, recovered, and pilot demodulated) by a demodulator 224 to provide symbols, and the symbols are further processed (e.g., decoded and checked) by a receive data processor 226 to recover the data and messages transmitted on the forward link. The recovered data is provided to a data sink 228, and the recovered messages may be provided to controller 230. Controller 230 may include instructions for registering mobile station 206, providing short-slot-cycle paging information to a base station (BS), receiving system parameter messages from the BS, determining whether the BS is capable of short-slot-cycle paging, indicating that the CD is also capable for short-slot-cycle paging if the BS is determined to be capable of short-slot-cycle paging, and setting or encoding a desired slot cycle duration.

[0034] The group call service (GCS) may allow one user to talk to a group of users in a half-duplex or full-duplex mode. In the former case, because only one person may be permitted to talk at a time, the permission to talk may be moderated by the infrastructure. In such systems, a user may request permission to talk by pressing a

“push-to-talk” button (PTT), for example. The system may arbitrate the requests received from multiple users and, through a contention-resolution process, the system may choose one of the requestors according to a predetermined algorithm. The system may then notify the chosen user that the user has permission to talk. The system may transparently dispatch the user’s traffic information, such as voice and/or data, from the authorized talker to the rest of the group members, who may be considered “listeners.” The voice and/or data traffic in GCS may be different from the classical one-to-one phone call, and a priority may be placed on some conversations.

[0035] FIG. 3 illustrates a group call arrangement **300** for showing how CDs **302**, **304**, and **306** interact with a group call server **308**. Multiple group call servers may be deployed as desired for large-scale groups. In FIG. 3, when CD **302** has permission to transmit media to other members of the group, CD **302** is known as the talker and may transmit media over an established channel. When CD **302** is designated as the talker, the remaining participants, CD **304** and CD **306**, may not have permission to transmit media to the group. Accordingly, CD **304** and CD **306** are designated as listeners. As described above, CDs **302**, **304**, and **306** are connected to group call server **308**, using at least one channel. In one embodiment, the channel may include a session initiation protocol (SIP) channel, a media-signaling channel, and a media traffic channel.

[0036] FIG. 4 illustrates a message-flow diagram showing a group call setup, according to one embodiment. A user who wishes to initiate a group call may select one or more target users, one or more pre-defined groups, or a combination of the two and may depress the push-to-talk (PTT) button on a CD, for example. The caller’s CD may then send a group call request **402** to the group call server to setup the group call. The caller’s CD may be in a dormant packet data session when the caller initiates the group call. The group call request may be transmitted regardless of whether the caller’s CD has a dedicated traffic channel or not. After the group call request is sent, if the caller’s CD is in dormant packet data session, the caller’s CD may initiate the process of re-establishing its dedicated traffic channel and prepare the packet data session for media activity.

[0037] When the group call server receives the group call request, the group call server may expand the pre-defined groups, if any is specified in the received group call request, into a list of group members. The group call server may retrieve location information for the desired target group members. The group call server may also

determine if the target group is already running in the system. FIG. 4 shows a scenario in which the group is not already running.

[0038] After the group call server locates at least one of the target group members, the group call server may send a response **404** back to the caller's CD indicating that the group call is being set up. At this point, the caller's CD may optimistically grant the caller's request to talk. The caller's CD may start buffering the received media for future transmission to the group call server. The group call server may use the location information of the target listeners' CDs to send out announcements **406** to the target listeners' CDs. Sending the announcements may trigger the packet data sessions of the target listeners' CDs to come out of dormancy and to re-establish their traffic channels. After at least one of the target listener's has responded to the group call announcements **406**, the group call server receives the response **408**, and delivers a group call response **410** to the caller's CD.

[0039] In one embodiment, the group communication system supports both chat-room and ad-hoc models for group call services. In the chat-room model, groups are predefined, which may be stored on the group call server. The predefined groups, or nets, may be public, implying that the group has an open member list. In this case, each group member is a potential participant in a group call. The group call is started when a first group member starts to initiate a group call. The call remains running for a pre-determined time period, which may be configured by the service provider. During a group call, the group members may specifically request to join or leave the call. During periods of talk inactivity, the group call may be brought into a group dormant state until a group member requests permission to talk. When operating in the chat-room model, group members, also known as net members, communicate with one another using a communication device assigned to each net member. The term "net" denotes a group of members authorized to communicate with each other.

[0040] In the ad-hoc model of group call services, however, groups may be defined in real-time and have a closed member list associated with each group. A closed member list may specify which members are allowed to participate in the group call. The member list may not be available to others outside of the closed member list, and may only exist for the life of the call. Ad-hoc group definitions may not be stored in the group call server. The definitions may be used to establish the group call and released after the call has ended. An ad-hoc group may be formed when a caller selects one or

more target members and generates a group call request, which is sent to the group call server to start the call. The group call server may send a notification to the target group members that they have been included in the group. The group call server may automatically join the target members into the group call, i.e., no action may be required from the target members. When an ad-hoc call becomes inactive, the group communication server may “tear down” the call and free the resources assigned to the group, including the group definition used to start the call.

[0041] The “instant response” relates to the call set up response time that starts with sending the group call request **402** from the caller’s CD and ends with receiving the group call response **410** by the caller’s CD. The goal for responding to the PTT or group call request is to consistently respond to the request within a predetermined time period, e.g., one and half seconds or less. In many cases, when a caller requests to setup a group call, the caller’s packet data session is *dormant*, meaning that no dedicated traffic channel exists. Re-establishing active channels may take considerable time. In one embodiment, group call server pages the target listeners’ CDs to locate the CDs.

[0042] FIG. 5 shows one embodiment for a slot cycle arrangement. For example, a slot cycle **502** of 1.28 seconds consists of 16 slots **504** of 0.08 seconds each. A dormant target CD monitors a predetermined one of such slots on forward paging channel (F-PCH) or forward common control channel (F-CCCH) of the wireless infrastructures serving the target CD. Base stations and mobile stations may advertise their slot cycles by designating a value for SLOT_CYCLE_INDEX (SCI), for example. The slot cycle duration, also known as paging delay, may be defined by $2^{SCI} \times 1.28$ seconds. In one embodiment, SCI takes positive values, such as 0, 1, 2, 3, 4, etc. However, for positive SCI values, longer paging delays cause call set ups to take longer time. As discussed above, for some applications, such as group call services, shorter call set ups are required. In one embodiment, SCI takes negative values, such as -1, -2, -3, and -4. Negative SCI values shorten paging delays and hence call set up delays.

[0043] FIG. 6 illustrates a flow diagram for providing short-slot-cycle paging in a base station. BS may advertise its capability of negative slot-cycle-index paging to the target CDs. For example, the BS may set, in step **602**, the AUTO_MSG_SUPPORTED field to “1” in the extended system parameter message (ESPM) or ANSI-41 system parameter message (A41SPM), to indicate whether BS supports negative slot-cycle-index paging. In step **604**, the BS that supports negative slot-cycle-index paging

receives and interprets the WLL_INCL field in the registration message (RM), origination message (OM), and page response message (PRM), from each of the target CDs. In step 606, if the WLL_INCL field is set to "1" in the received registration message, origination message, or page response message, indicating that the CD that sent one of these messages is also capable of negative slot-cycle-index paging, the BS interprets the slot-cycle-index value as being negative, as shown in Table 1.

[0044] In step 608, the BS examines whether the received slot cycle index, which may be in binary-number form, has a decimal value of 5, 6, or 7. If the received slot cycle index has a decimal value of 5, 6, or 7, an error message is generated in step 610, meaning that paging cycle may not be shorter than a single slot, e.g., 0.080 seconds. Otherwise, if the received slot cycle index has a decimal value of 0, 1, 2, 3, or 4, the BS interprets the received slot-cycle-index value as being negative, in step 612. A slot-cycle-index value of -1 causes the BS to page the target CD every eight slots, or every 0.64 seconds. A slot cycle index value of -2 causes the BS to page the target CD every four slots, or every 0.32 seconds. A slot cycle index value of -3 causes the BS to page the target CD every two slots, or every 0.16 seconds. A slot cycle index value of -4 causes the BS to page the target CD every slot, or every 0.08 seconds, providing a relatively shorter slot cycle paging.

[0045] However, if in step 606 the WLL_INCL field is set to "0" in the registration message, origination message, or page response message, indicating that the CD that sent one of these messages is not capable of negative-slot-index paging, the BS interprets, in step 614, the slot cycle index value as being positive, as shown in Table 1. A slot-cycle-index value of "0" causes the BS to page the target CD every 16 slots, or every 1.28 seconds. A slot-cycle-index value of 1 causes the BS to page the target CD every 32 slots, or every 2.56 seconds. A slot-cycle-index value of 2 causes the BS to page the target CD every 64 slots, or every 5.12 seconds. A slot cycle-index-value of 3 causes the BS to page the target CD every 128 slots, or every 10.24 seconds. Similarly, a slot-cycle-index value of 7 causes the BS to page the target CD every 2048 slot, or every 163.84 seconds, providing a relatively longer slot cycle paging.

Table 1

SLOT CYCLE_INDEX	WLL_INCL	Slot Cycle Length
111	1	Failure condition
100	1	Failure condition
101	1	Failure condition
100	1	0.08s (1 slot)
011	1	0.16s (2 slots)
010	1	0.32s (4 slots)
001	1	0.64s (8 slots)
000	1 or 0	1.28s (16 slots)
001	0	2.56s (32 slots)
010	0	5.12s (64 slots)
011	0	10.24s (128 slots)
100	0	20.48s (256 slots)
101	0	40.96s (512 slots)
110	0	81.92s (1024 slots)
111	0	163.84s (2048 slots)

[0046] FIG. 7 illustrates a flow diagram for providing short-slot-cycle paging in a target CD, according to one embodiment. Each target CD may advertise its capability of negative or shorter slot cycle paging to the BS. For example, in step 702, a CD receives and interprets the field AUTO_MSG_SUPPORTED in the extended system parameter message (ESPM) or ANSI-41 system parameter message (A41SPM), to determine whether the BS is capable of short-slot-cycle paging. In step 704, if the CD determines that the BS has set the AUTO_MSG_SUPPORTED field to “1,” indicating that the BS is capable of short-slot-cycle paging, the CD that is also capable of short-slot-cycle paging sets, in step 706, the WLL_INCL field to “1” in the registration message, origination message, or page response message. As discussed above, these messages indicate to the BS that the target CD is capable of short-slot-cycle paging, and the associated slot cycle index may be considered negative, as discussed above and shown in Table 1. In step 708, the CD sets a desired slot cycle duration by specifying or encoding a slot cycle index.

[0047] In step 704, if the CD determines that the BS has set the AUTO_MSG_SUPPORTED field to “0,” indicating that the BS is not capable of short-slot-cycle paging, the CD sets, in step 710, the WLL_INCL field to “0” in the registration message, origination message, or page response message. As discussed

above, these messages indicate to the BS that the target CD is not capable of short-slot-cycle paging, and the associated slot cycle index may be considered being positive, as discussed above and shown in Table 1.

[0048] FIG. 8 illustrates a flow diagram for providing short-slot-cycle paging in a base station, in one embodiment. The BS may advertise its capability of negative slot-cycle-index paging to the target CDs. For example, the BS may set, in step 802, the AUTO_MSG_SUPPORTED field to “1” in the extended system parameter message (ESPM) or ANSI-41 system parameter message (A41SPM), to indicate whether BS supports negative slot-cycle-index paging. In step 804, the BS that supports negative slot-cycle-index paging receives and interprets the WLL_INCL field in the registration message (RM), origination message (OM), and page response message (PRM), from each of the target CDs. In step 806, if the WLL_INCL field is set to “1” in the received registration message, origination message, or page response message, indicating that the CD that sent one of these messages is also capable of negative slot-cycle-index paging, the BS interprets the slot-cycle-index value as being negative, as shown in Table 1.

[0049] In step 808, the BS examines whether the CD that supports short slot cycle has set a value for shorter slot cycle paging. In one embodiment, the CD may set such value in a WLL-DEVICE_TYPE filed, as shown in Table 2. The BS may store the specified short slot cycle duration in a database and page the target CD that is capable of short slot cycle paging based on the stored value.

Table 2

WLL_DEVICE_TYPE (binary)	Shorter Slot Cycle Representation	Slot Cycle Length
001	-1	0.64s (8 slots)
010	-2	0.32s (4 slots)
011	-3	0.16s (2 slots)
100	-4	0.08s (1 slot)

[0050] If the content of the WLL-DEVICE_TYPE field is set to a decimal value of 1, 2, 3, or 4, the BS interprets the received value as a negative slot-cycle-index, in step 810. A slot-cycle-index value of -1 causes the BS to page the target CD every eight slots, or

every 0.64 seconds. A slot cycle index value of -2 causes the BS to page the target CD every four slots, or every 0.32 seconds. A slot cycle index value of -3 causes the BS to page the target CD every two slots, or every 0.16 seconds. A slot cycle index value of -4 causes the BS to page the target CD every slot, or every 0.08 seconds, providing a relatively shorter slot cycle paging.

[0051] However, if in step **806**, the WLL_INCL field is set to “0” in the registration message, origination message, or page response message, indicating that the CD that sent one of these messages is not capable of negative-slot-index paging, the BS interprets, in step **814**, the slot cycle index value as being positive, as discussed above.

[0052] FIG. 9 illustrates a flow diagram for providing short-slot-cycle paging in a target CD, according to one embodiment. Each target CD may advertise its capability of negative or shorter slot cycle paging to the BS. For example, in step **902**, a CD receives and interprets the field AUTO_MSG_SUPPORTED in the extended system parameter message (ESPM) or ANSI-41 system parameter message (A41SPM), to determine whether the BS is capable of short-slot-cycle paging. In step **904**, if the CD determines that the BS has set the AUTO_MSG_SUPPORTED field to “1,” indicating that the BS is capable of short-slot-cycle paging, the CD that is also capable of short-slot-cycle paging sets, in step **906**, the WLL_INCL field to “1” in the registration message, origination message, or page response message. As discussed above, these messages indicate to the BS that the target CD is capable of short-slot-cycle paging, and the associated slot cycle index be considered negative, as discussed above and shown in Table 2. In step **908**, the CD may set a desired slot cycle duration by specifying or encoding the WWL-DEVICE-TYPE filed.

[0053] In step **904**, if the CD determines that the BS has set the AUTO_MSG_SUPPORTED field to “0,” indicating that the BS is not capable of short-slot-cycle paging, the CD sets, in step **910**, the WLL_INCL field to “0” in the registration message, origination message, or page response message. As discussed above, these messages indicate to the BS that the target CD is not capable of short-slot-cycle paging, and the associated slot cycle index be considered positive, as discussed above.

[0054] FIG. 10 illustrates a flow diagram for providing short-slot-cycle paging in a base station. BS may advertise its capability of negative slot-cycle-index paging to the target CDs. For example, the BS may set, in step **1002**, the AUTO_MSG_SUPPORTED field

to “1” in the extended system parameter message (ESPM) or ANSI-41 system parameter message (A41SPM), to indicate whether BS supports negative slot-cycle-index paging. In step 1004, the BS that supports negative slot-cycle-index paging receives and interprets the slot-cycle-index field in the registration message (RM), origination message (OM), and page response message (PRM), from each of the target CDs. In step 1006, if the most significant bit (MSB) of the slot-cycle-index field is set to “1,” indicating that the CD that sent one of these messages is also capable of negative slot-cycle-index paging, the BS interprets the slot-cycle-index value as being negative, as shown in Table 3.

[0055]

Table 3

SLOT_CYCLE_INDEX (binary)	Old Definition (in CDMA2000 standard)	New Definition
100	20.48s (256 slots)	0.08s (1 slot)
101	40.96s (512 slots)	0.16s (2 slots)
110	81.92s (1024 slots)	0.32s (4 slots)
111	163.84s (2048 slots)	0.64s (8 slots)

[0056] If the content of the slot-cycle-index field is set to a decimal value of 4, 5, 6, or 7, the BS interprets the received value as a negative slot-cycle-index, in step 1008. A slot-cycle-index value of 4 causes the BS to page the target CD every slot, or every 0.08 seconds, providing a relatively shorter slot cycle paging. A slot cycle index value of 5 causes the BS to page the target CD every two slots, or every 0.16 seconds. A slot cycle index value of 6 causes the BS to page the target CD every four slots, or every 0.32 seconds. A slot cycle index value of 7 causes the BS to page the target CD eight slot, or every 0.64 seconds. However, if in step 1006, the MSB of the slot-cycle-index is determined to be “0,” indicating that the CD that sent one of these messages is not capable of negative-slot-index paging, the BS interprets the slot cycle index value as being positive, as shown in Table 1.

[0057] FIG. 11 illustrates a flow diagram for providing short-slot-cycle paging in a target CD, in one embodiment. Each target CD may advertise its capability of negative

or shorter slot cycle paging to the BS. For example, in step **1102**, a CD receives and interprets the field AUTO_MSG_SUPPORTED in the extended system parameter message (ESPM) or ANSI-41 system parameter message (A41SPM), to determine whether the BS is capable of short-slot-cycle paging. In step **1104**, if the CD determines that the BS has set the AUTO_MSG_SUPPORTED field to “1,” indicating that the BS is capable of short-slot-cycle paging, the CD that is also capable of short-slot-cycle paging sets or codes, in step **1106**, the desired short slot cycle duration by specifying or encoding a slot-cycle-index with the MSB of “1” in the registration message, origination message, or page response message. As discussed above, these messages indicate to the BS that the target CD is capable of short-slot-cycle paging, and the associated slot cycle index may be considered negative, as discussed above and shown in Table 3.

- [0058] In step **1104**, if the CD determines that the BS has set the AUTO_MSG_SUPPORTED field to “0,” indicating that the BS is not capable of short-slot-cycle paging, the CD interprets, in step **1108**, the slot-cycle-index with MSB of “0” as being positive, as discussed above and shown in Table 1
- [0059] Therefore, the disclosed embodiments provide for a significant reduction in paging delays when paging a group of target mobile stations in a group communication system. The disclosed methods and apparatus also provide for faster call set ups by optimizing the registration and paging of the mobile stations.

[0060] Those of skill in the art would understand that information and signals may be represented using any of a variety of different technologies and protocols. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0061] Those of skill would further appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular

application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present invention.

[0062] The various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but, in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0063] The steps of a method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EEPROM memory, EEPROM memory, registers, a hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor, such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a user terminal.

[0064] The description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to these embodiments may be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments, e.g., in an instant messaging service or any general wireless data communication applications, without departing from the spirit or scope of the invention. Thus, the present invention is not

intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein. The word "exemplary" is used exclusively herein to mean "serving as an example, instance, or illustration."